The Effects of Clouds and Aerosols on the Radiation Balance Inferred from CloudSat, CALIPSO, and MODIS Observations

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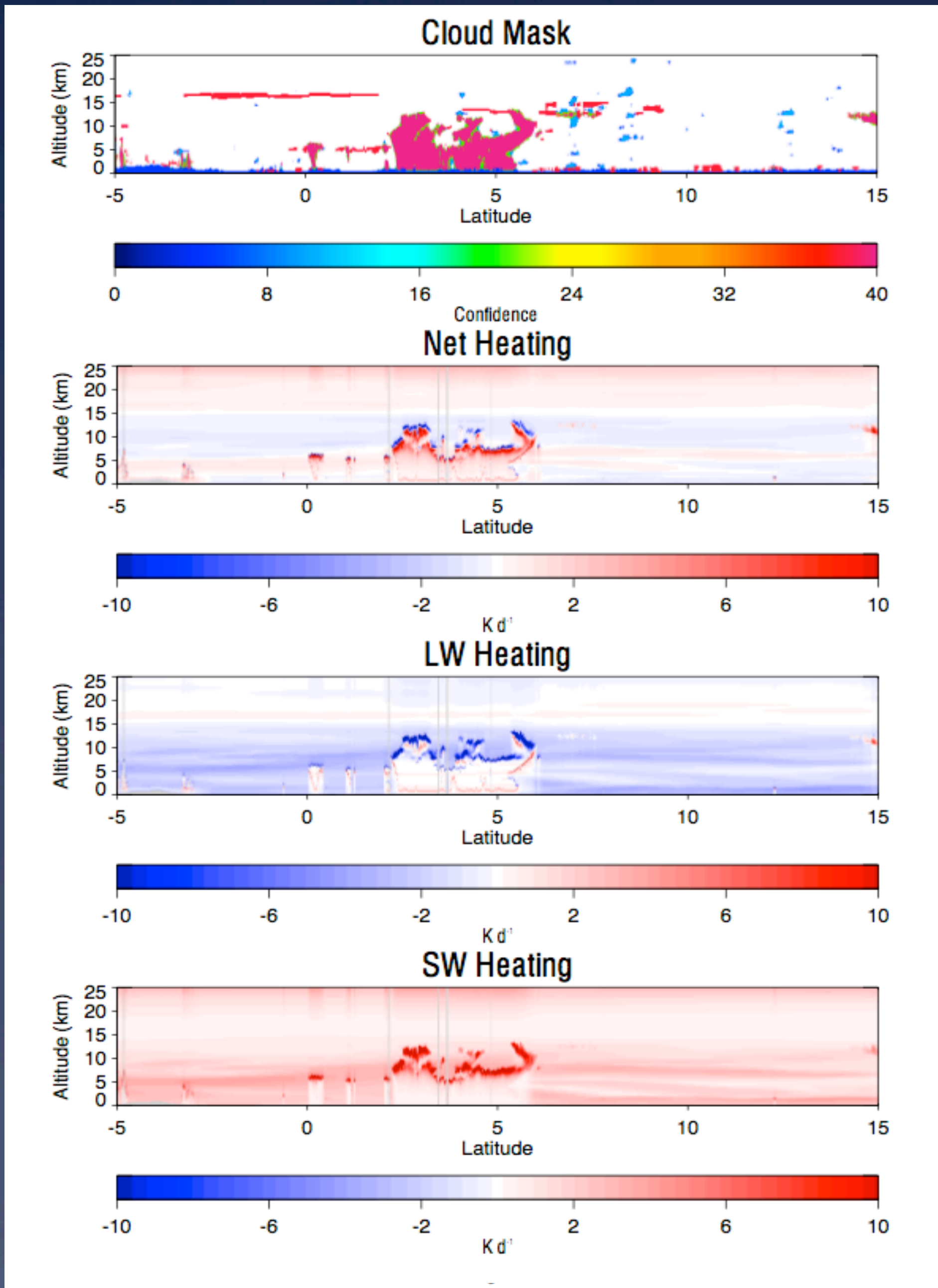
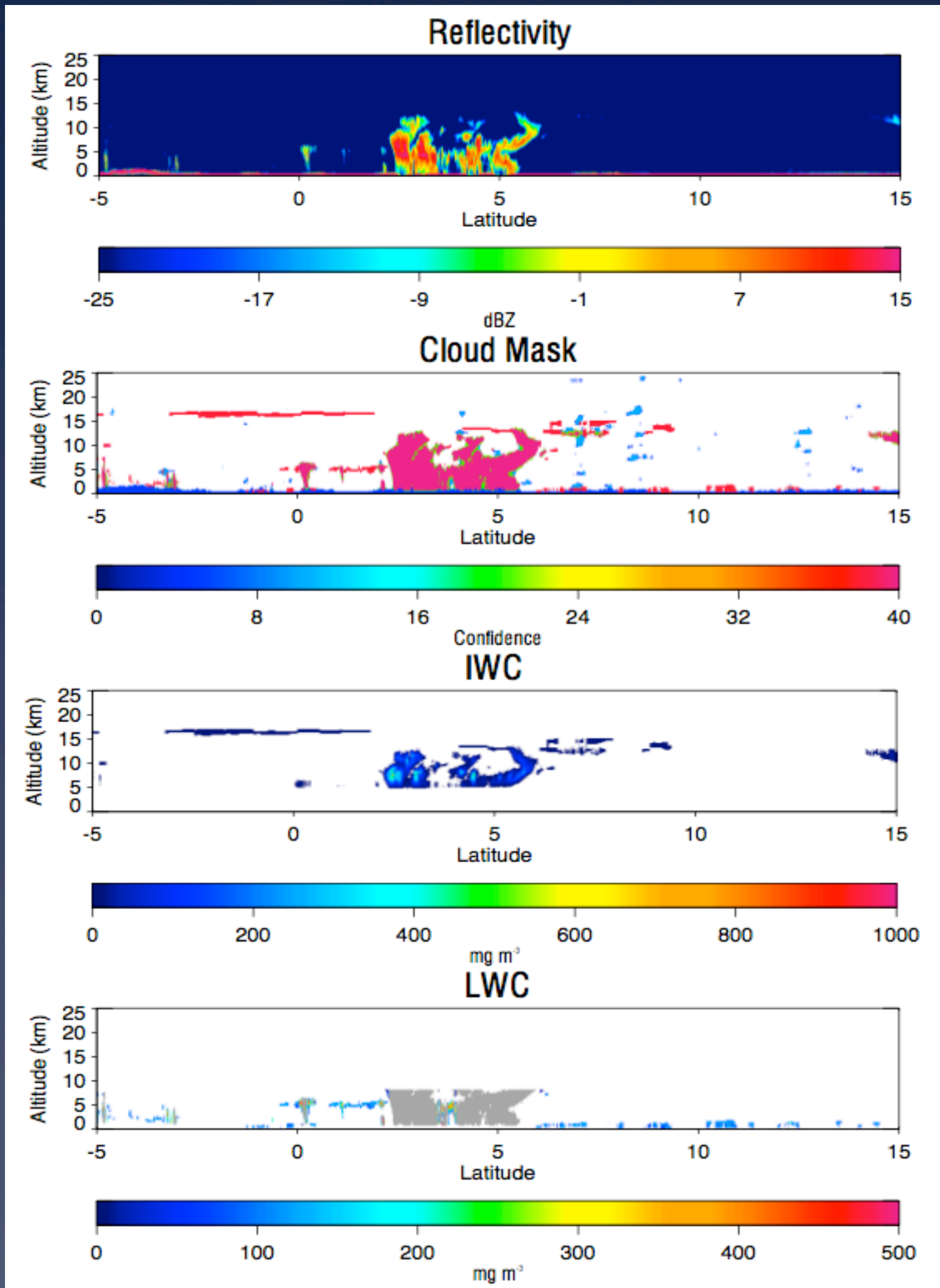
Overview

- Brief discussion of current FLXHR product
- Detecting and finding properties of new clouds, aerosols, and precipitation for FLXHR-Lidar
- Effects of new clouds on Radiation Balance
  - Cases where clouds, aerosol, and precipitation are added
  - Comparisons with CERES FLASHflux product
- Future development on FLXHR-LIDAR product



Current FLXHR Product

- Vertical distributions of LWC, IWC, and liquid and ice effective radii, are inputted from CloudSat's 2B-CWC Product
- Temperature and relative humidity profiles from ECMWF
- Surface albedo and emissivity from the International Geosphere-Biosphere Programme (IGBP)
- Inputted into the Radiative transfer model
- Outputs contain:
  - Vertical profiles of upwelling and downwelling LW and SW fluxes
  - Vertical profiles of radiative heating



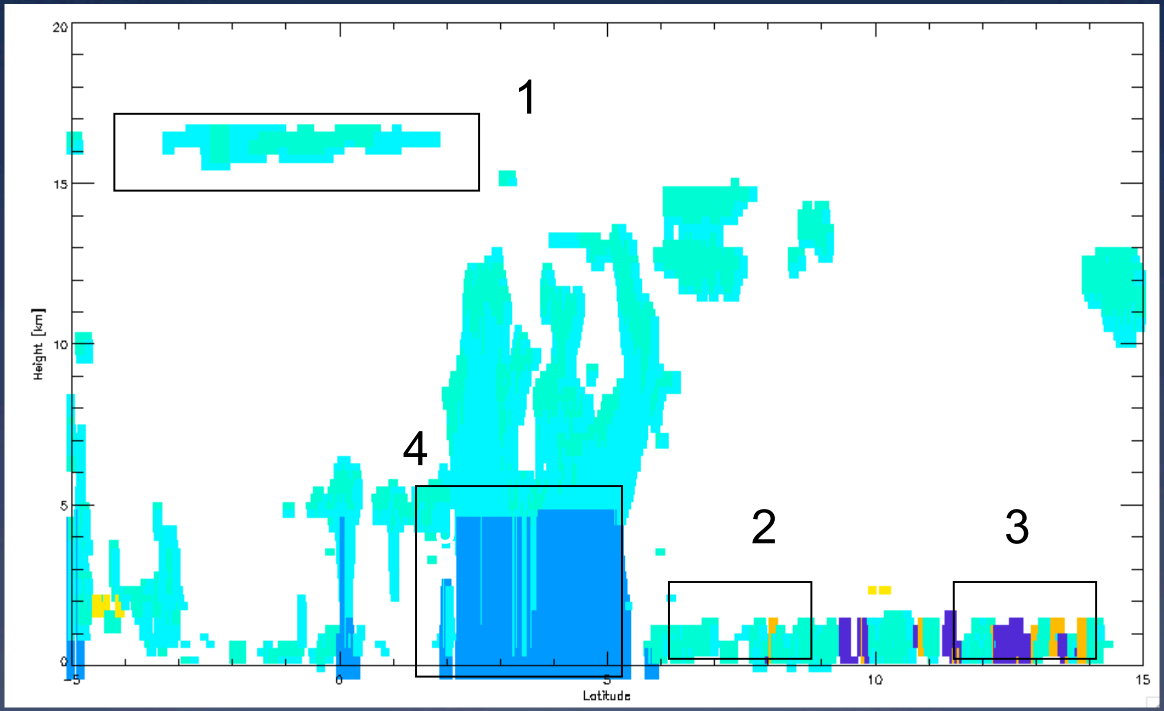
Current FLXHR Product Cont.

- Thin subvisible cirrus clouds are not detected by the CloudSat CPR because their reflectivities are below the minimal detectable signal of -30 dB
- Low clouds are either below the minimal detectable signal or considered clutter clouds (below 1 km), because of contamination from surface reflectivity
- Unable to determine properties of aerosols or precipitation if present

FLXHR-Lidar Product

- Goals:
  - Find Subvisible cirrus, low clouds, aerosol, and precipitation that are not detected by CloudSat
  - Determine properties of these new features
  - Run radiative transfer model with new features added
  - Calculate the effects of the new features on the Earth's Radiative Balance

Classifying Cloud and Aerosols



1. Subvisible Cirrus – 2B-Geoprof-Lidar
2. Low Clouds – 2B-Geoprof-Lidar/2B-CWC-RVOD
3. Aerosol – CALIPSO 5 km Aerosol Layer Product
4. Precipitation – 2B-CWC-RVOD/2C-PRECIP-COLUMN

Cloud and Aerosol Properties

- All Clouds
  - If MODIS information is available, Cloud properties are derived from 2B-CWC-RVOD

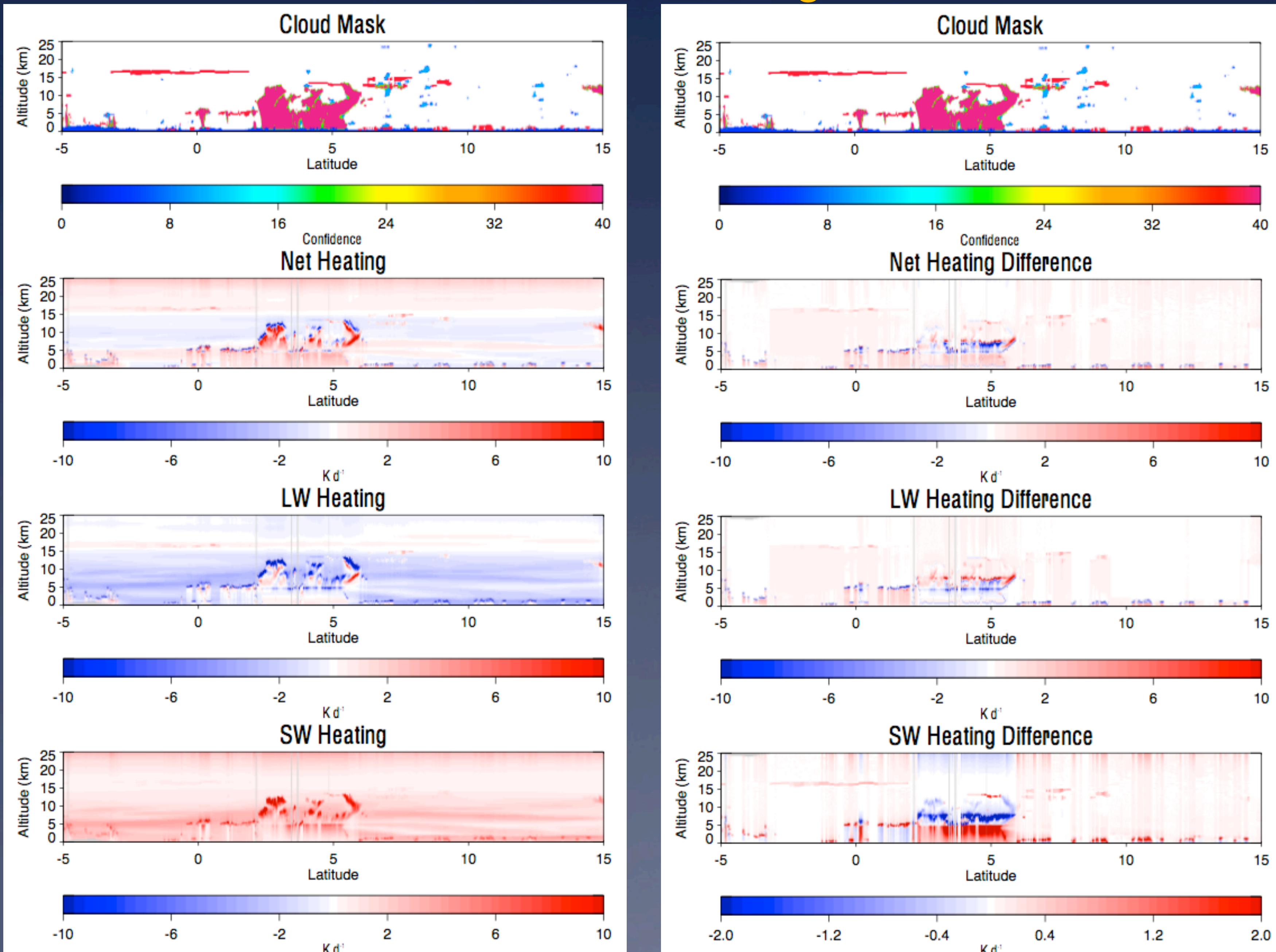
- Cirrus
  - Optical depths (OD) calculated using lidar-transmission method. If OD cannot be calculated OD from CALIPSO 5km Cloud Layer Product is used. Clouds given R_e=30μm and IWC calculated from cloud optical depth

- Low clouds
  - Where MODIS is available, R_e is calculated from 2B-Tau (Merged MODIS Product)
  - Else, R_e=18μm $LWC_{<1km}$=120mgm^{-3} or $LWC_{>1km}$=50mgm^{-3}

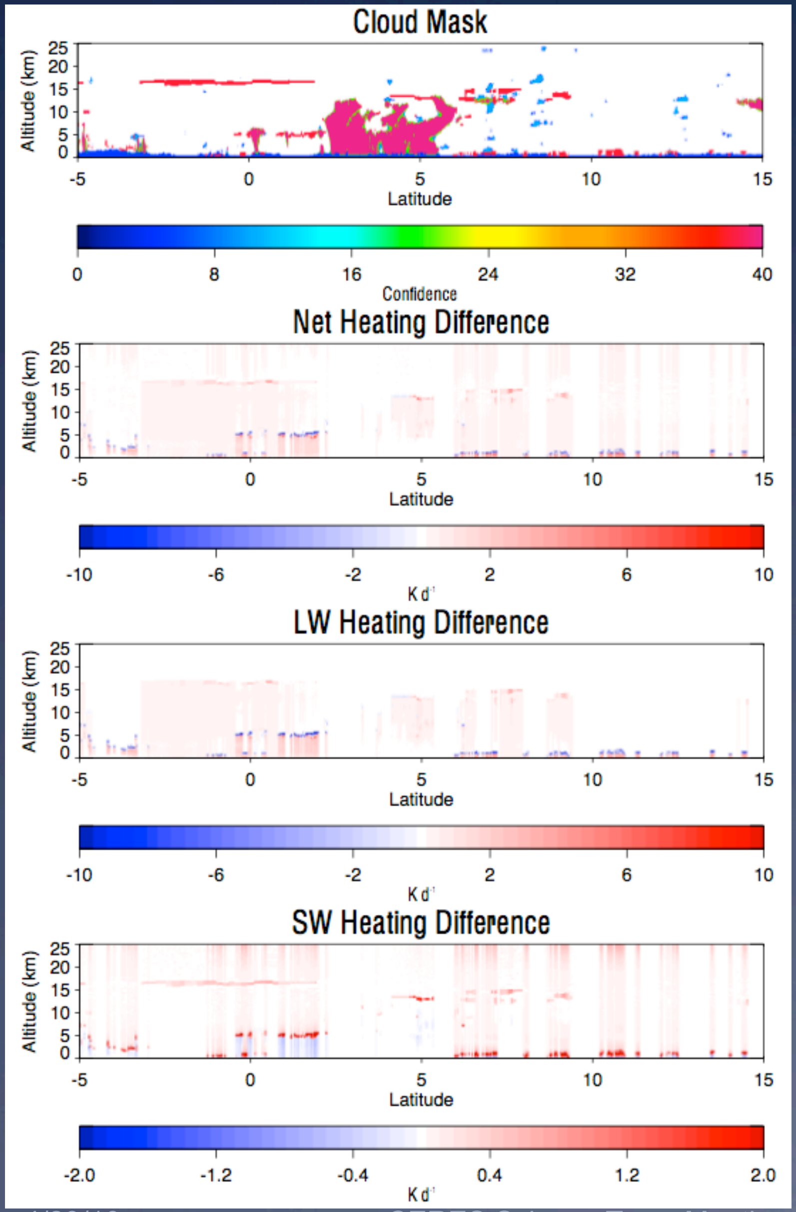
- Aerosol
  - Aerosol OD taken from CALIPSO 5km Aerosol Layer Product
  - OD used in SPRINTARS Aerosol Model to find aerosol properties

- Precipitation
  - Precipitation is located using 2C-PRECIP-Column. 500 gm^{-2} in precipitation is divided through column up to freezing level. Drop size given by Marshall-Palmer distribution. 125gm^{-2} of cloud water divided through column with R_e=18μm

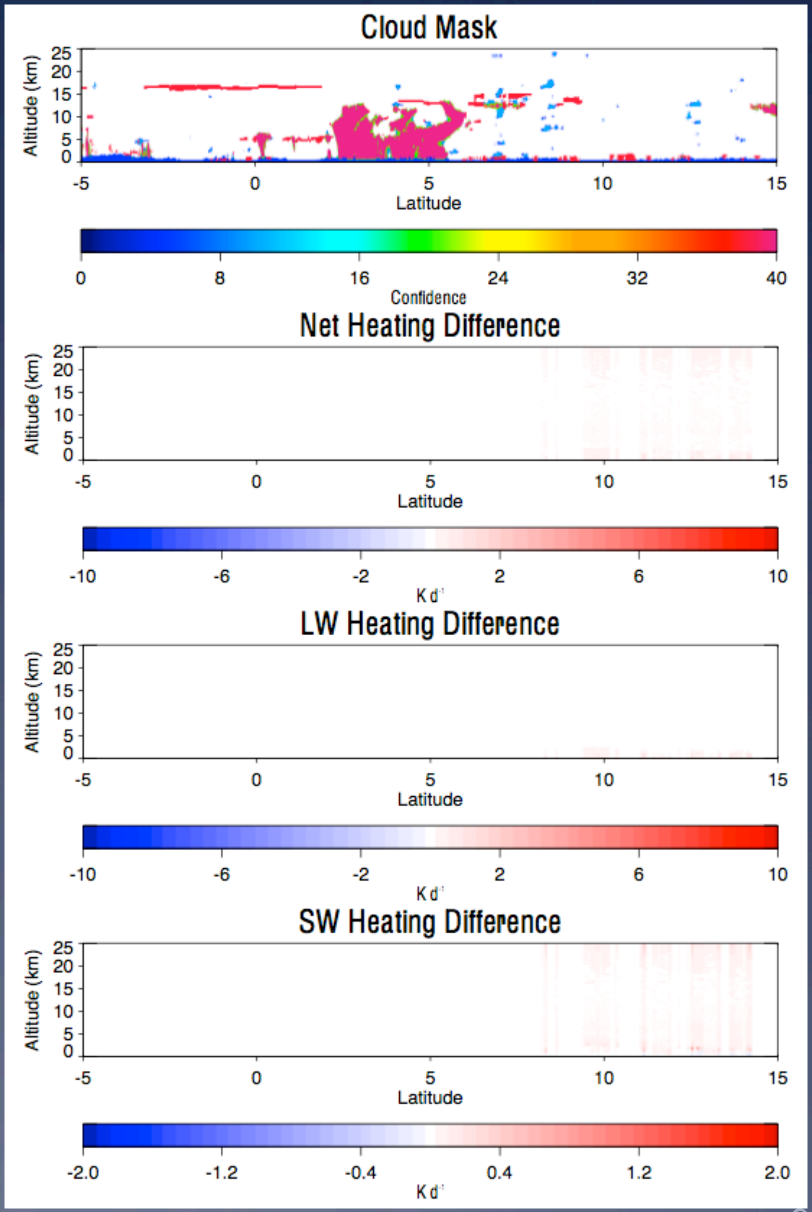
FLXHR-LIDAR Heating Rates



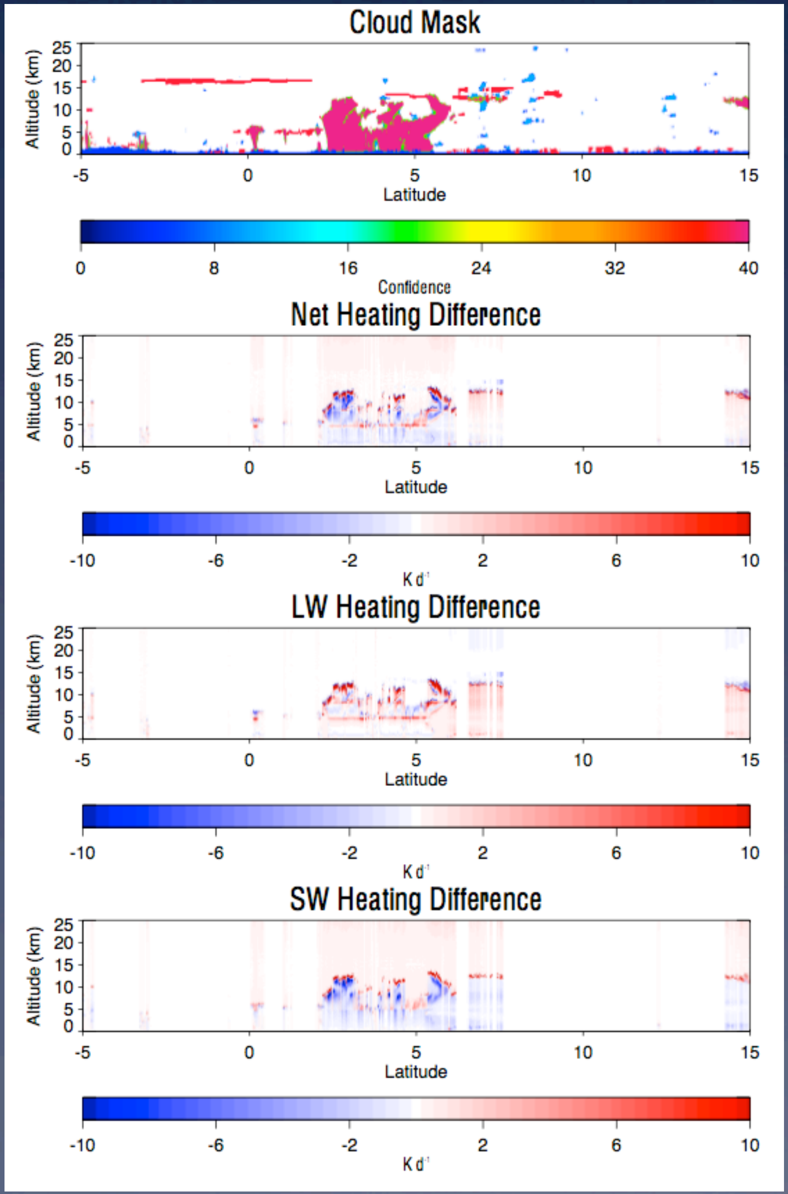
Add Cirrus and Low Clouds



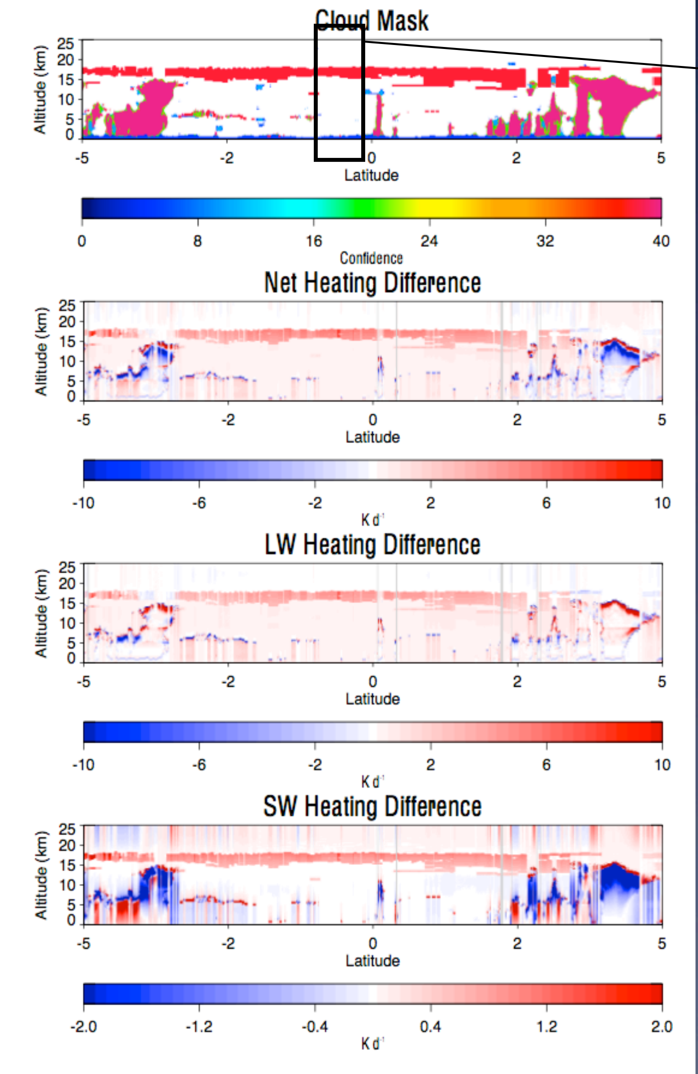
Add Aerosol

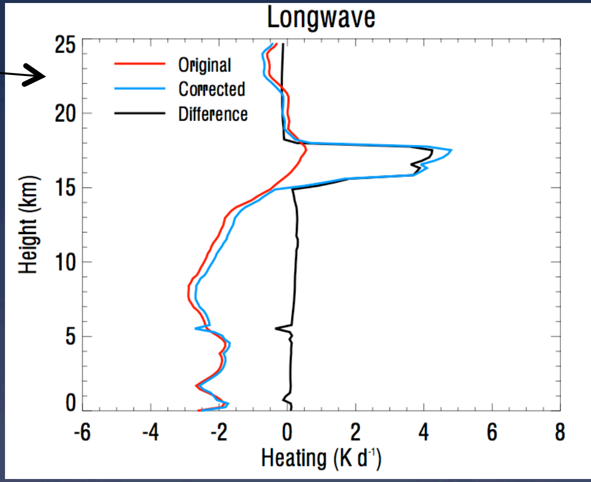


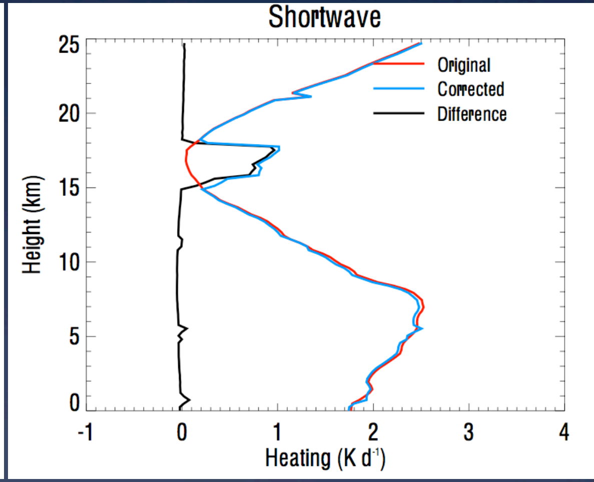
Add Precipitation

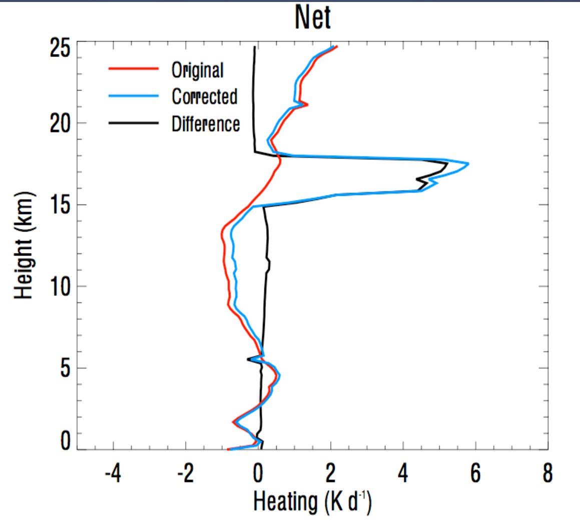


Cirrus



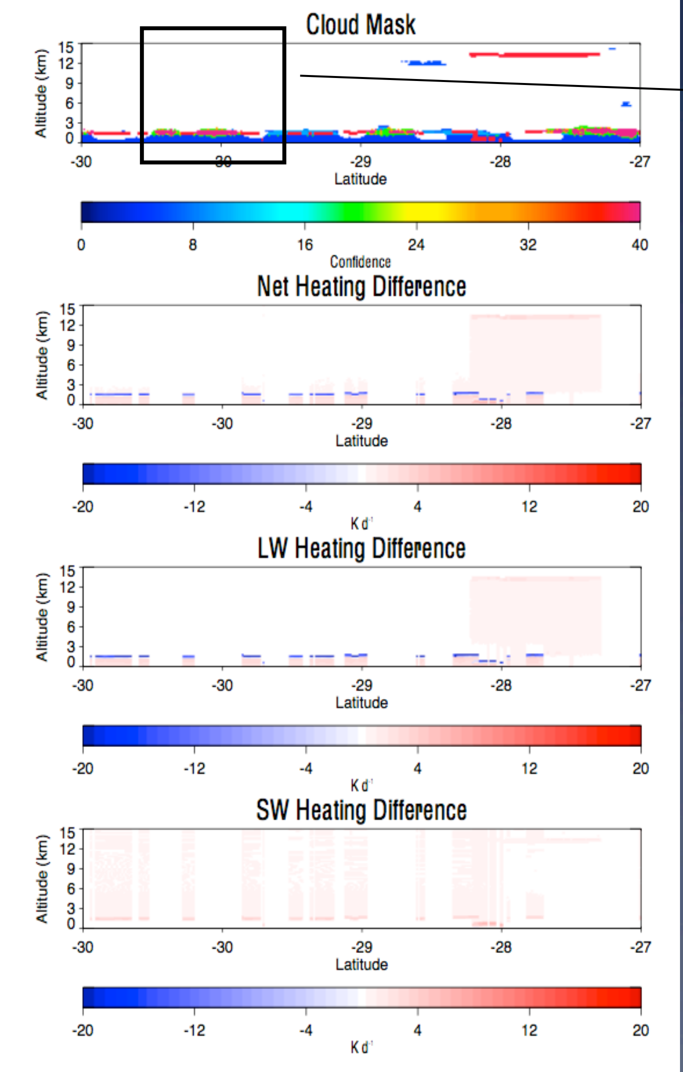


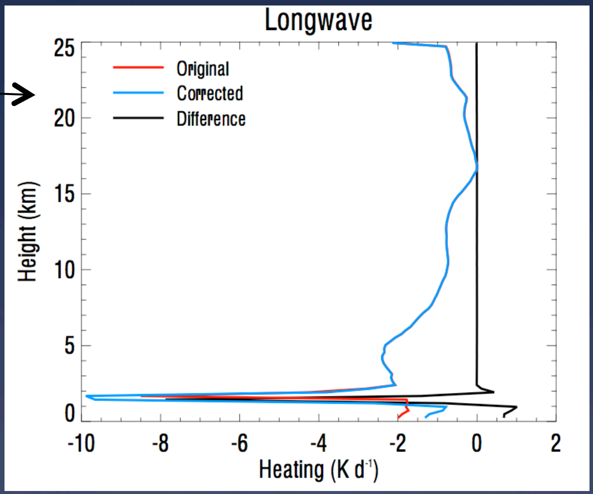


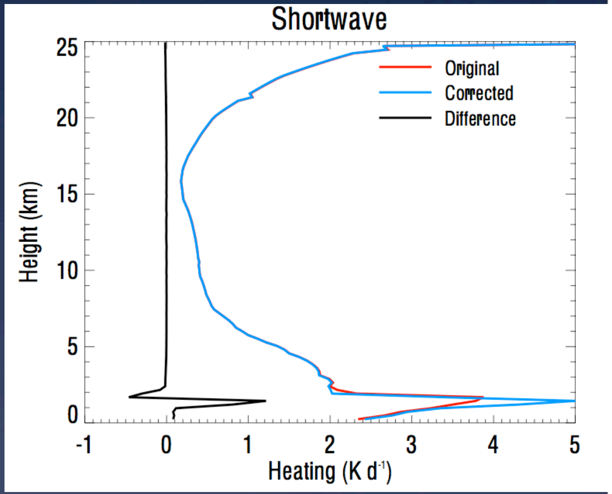


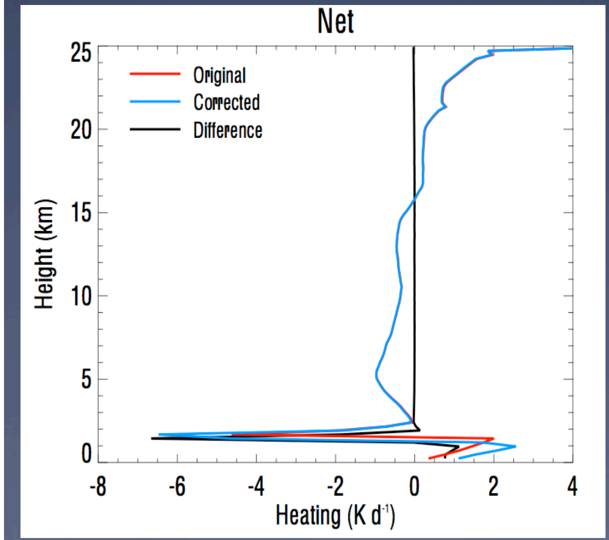
Heating near 16km and below due to LW heat being trapped below cirrus

Low Cloud





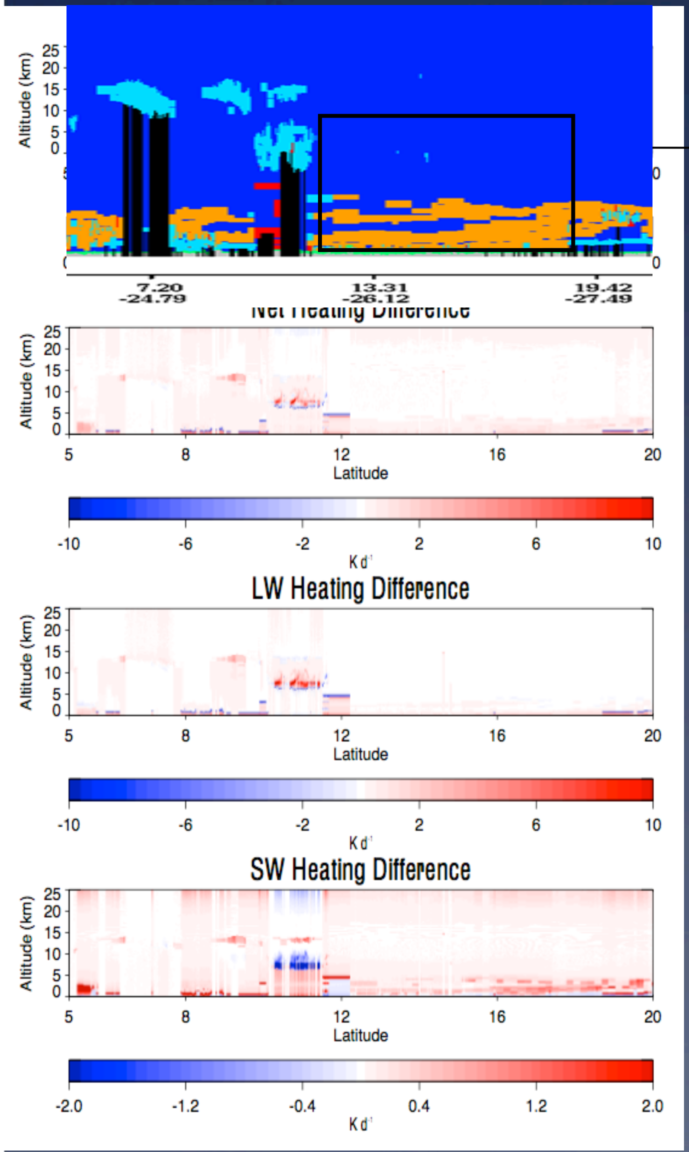


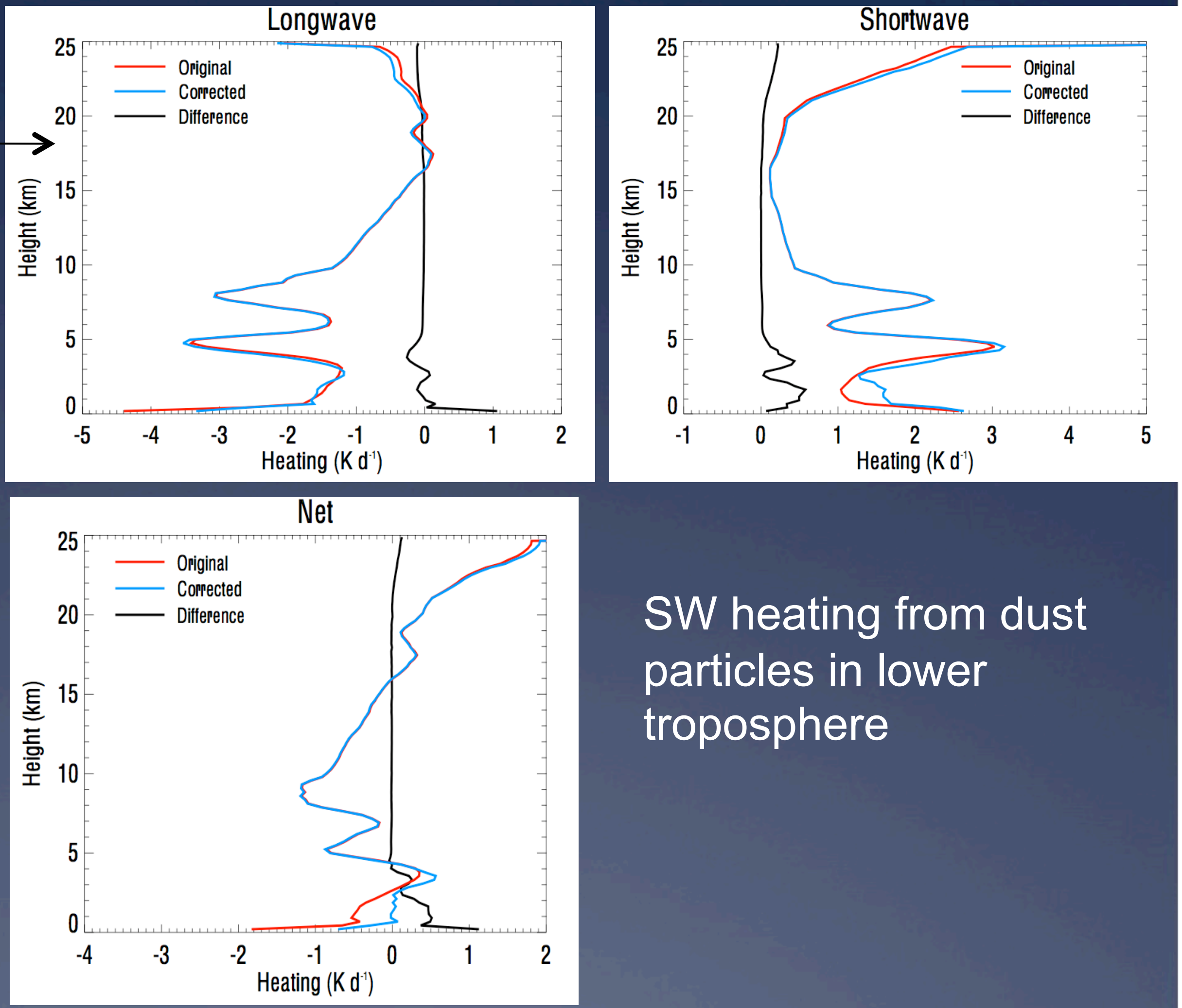


LW heating below cloud and cooling at cloud top

SW Heating at cloud top and above cloud

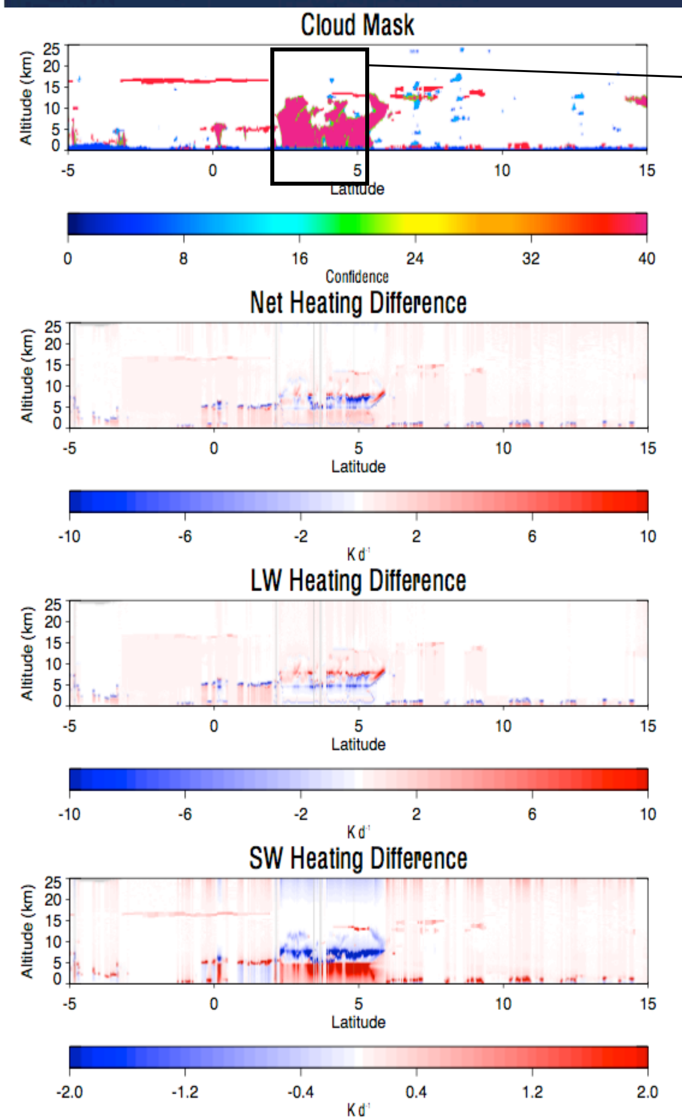
Aerosol

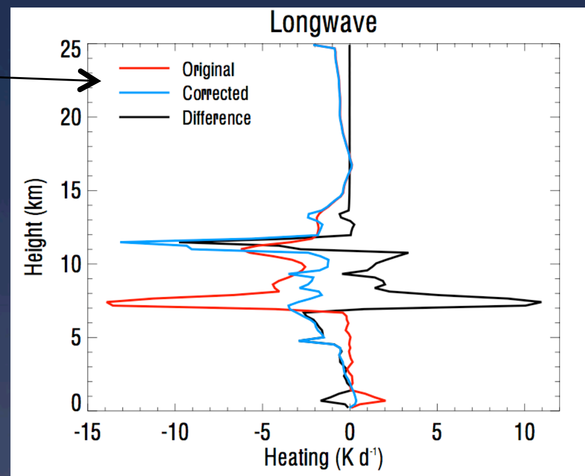


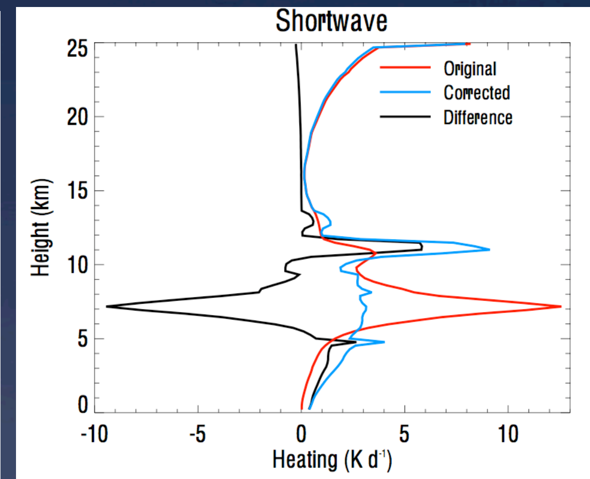


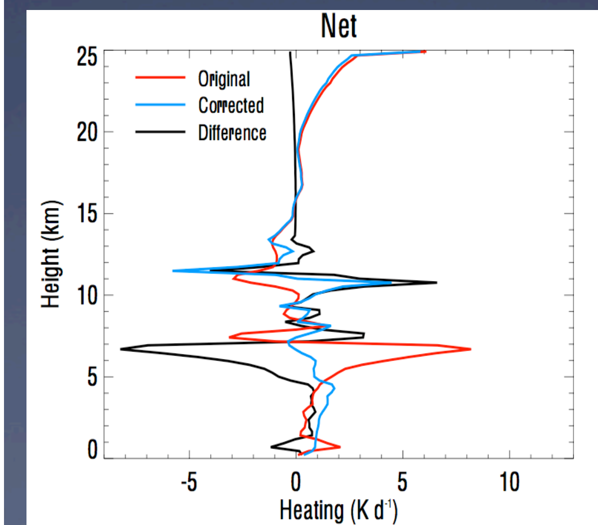
SW heating from dust particles in lower troposphere

Precipitation









Fixed large spike in at ~8km

Changes at cloud top due to RVOD

FLXHR and FLXHR-LIDAR Comparison with CERES FLASHflux Data

- CloudSat and CERES data are binned into 5 degree boxes over the month of January 2007

- CERES Data: CERES FLASHFlux Aqua-Version2A

- CloudSat Data: 2B-FLXHR
- 2B-FLXHR-LIDAR (Beta)

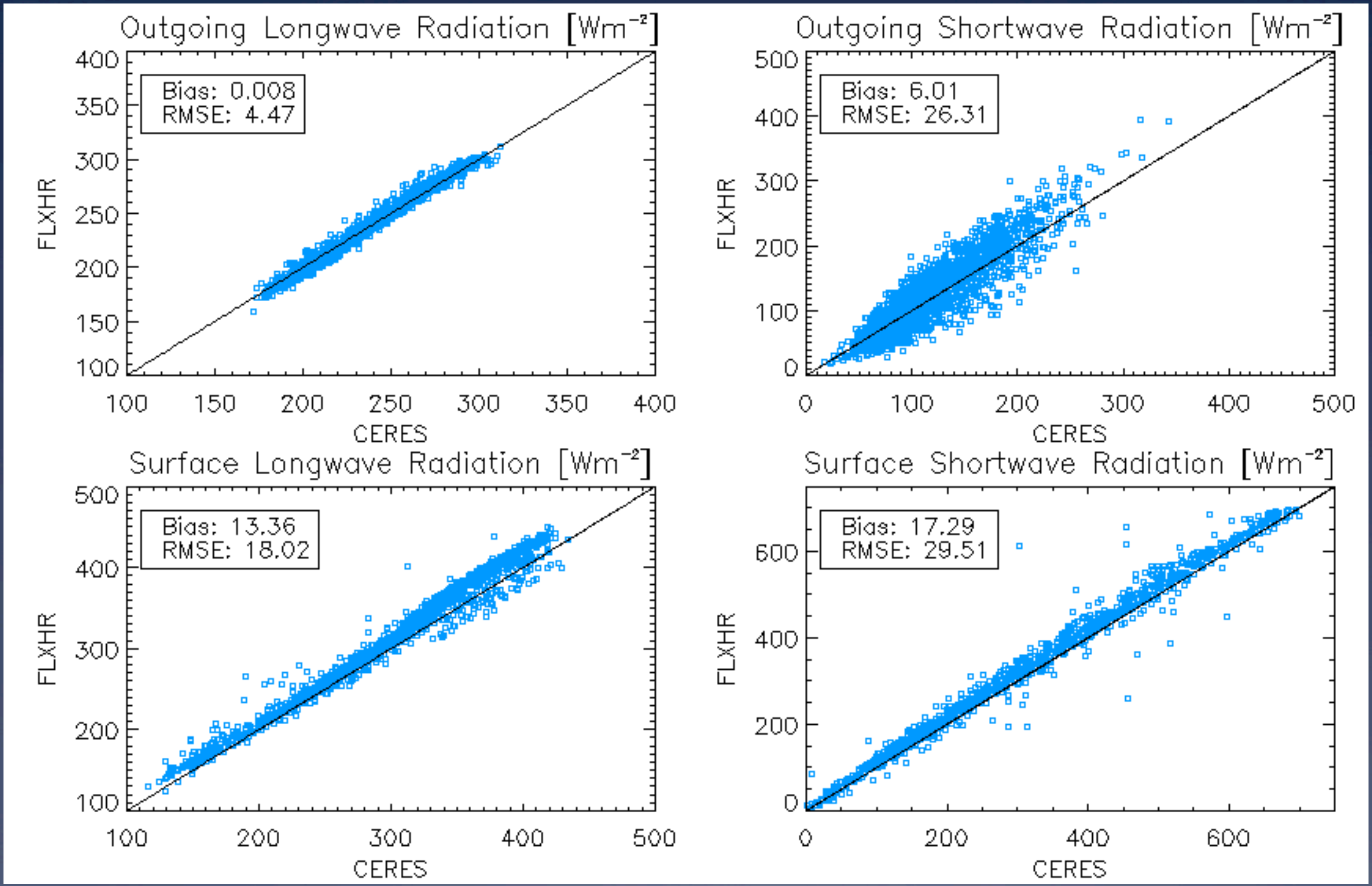
- CERES data is matched to closest CloudSat data point

- Data are compared by OLR,OSR,SLR, and SSR

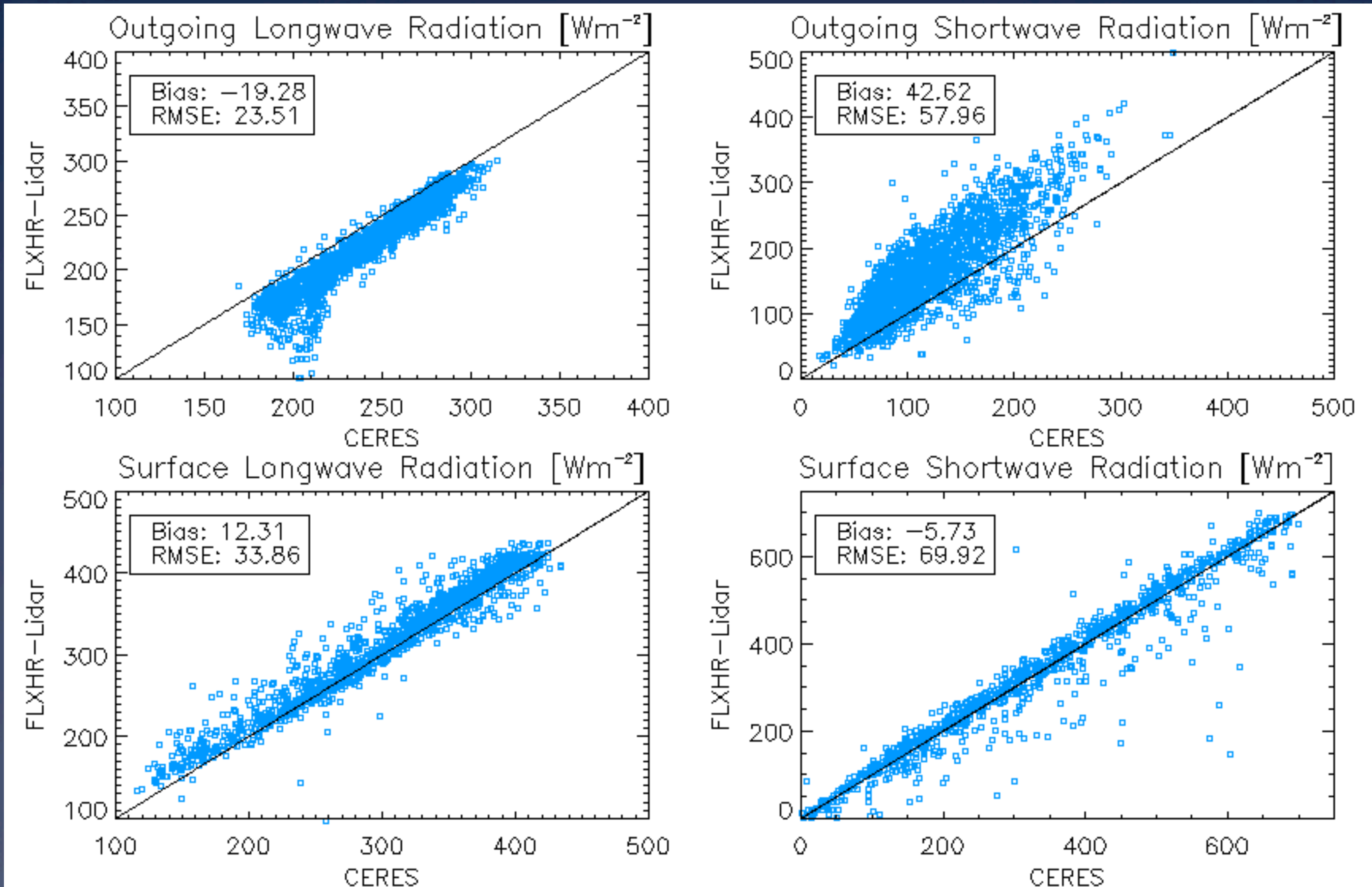
- FLXHR-Lidar is broken in two cases:
- CALIPSO high clouds only
- CALIPSO low clouds only

- Some scatter is expected due to the larger swath for CERES

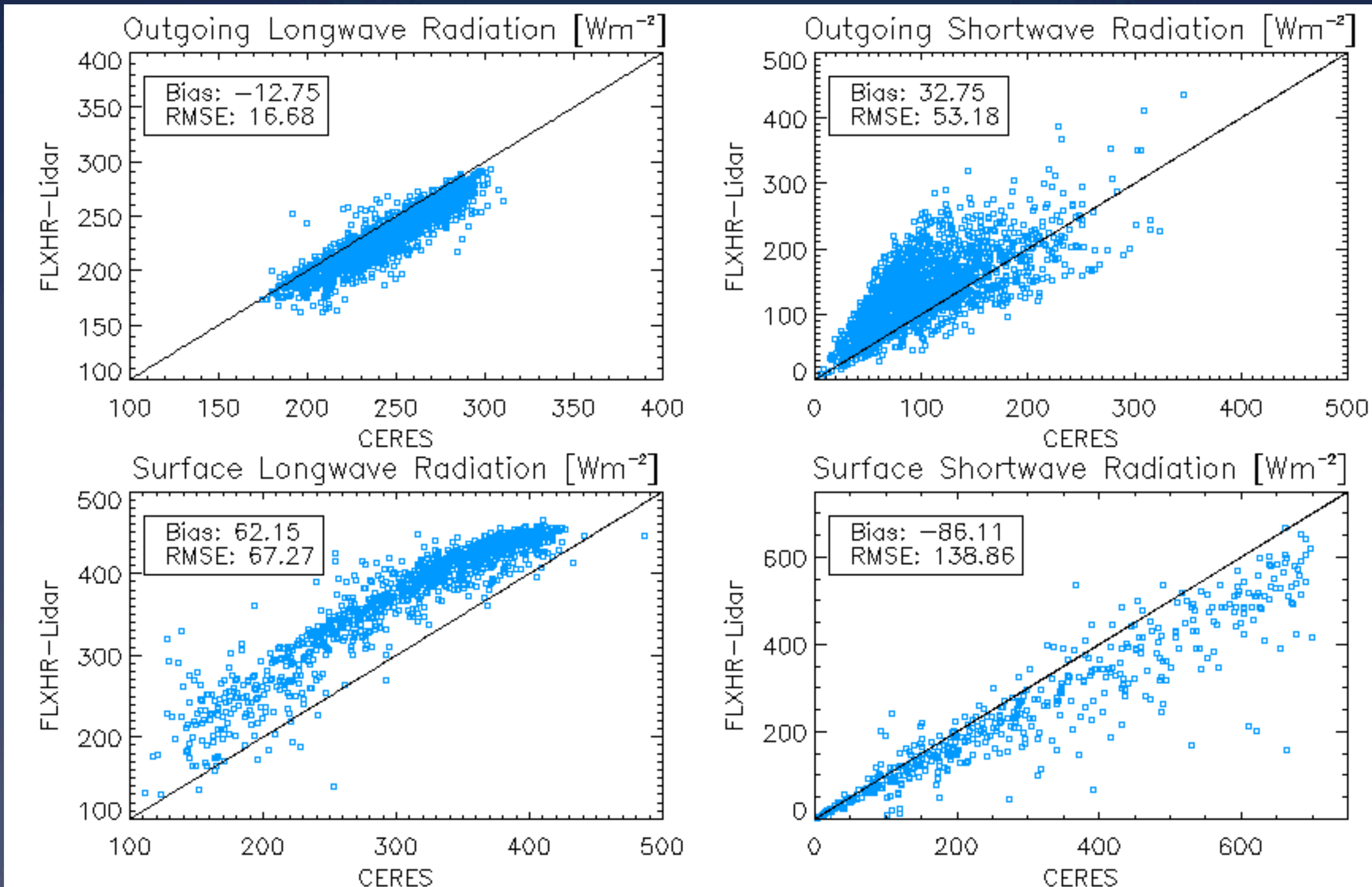
FLXHR-CERES Comparison



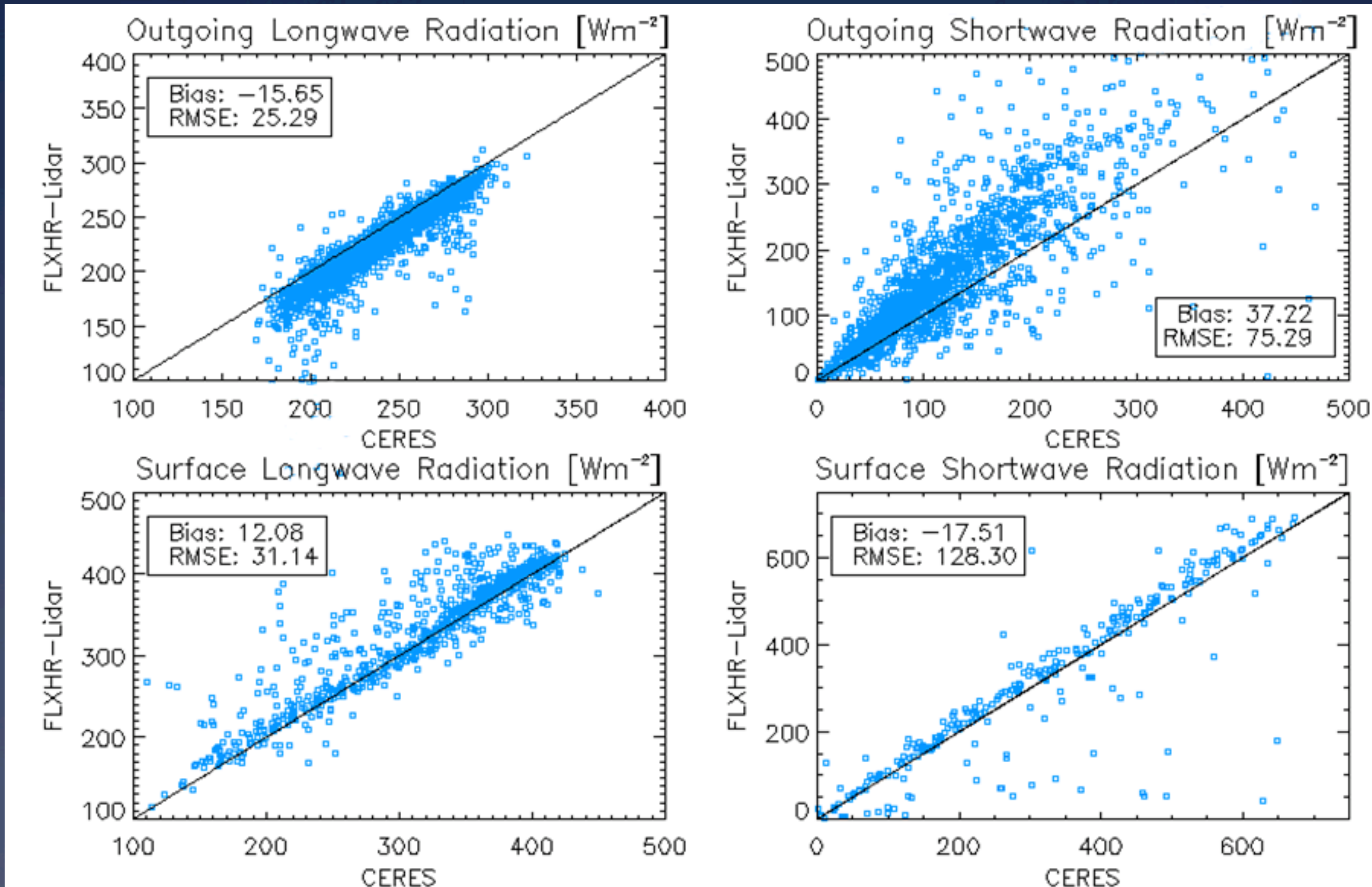
FLXHR-LIDAR-CERES Comparison



FLXHR-LIDAR-CERES Comparison Low Clouds Only

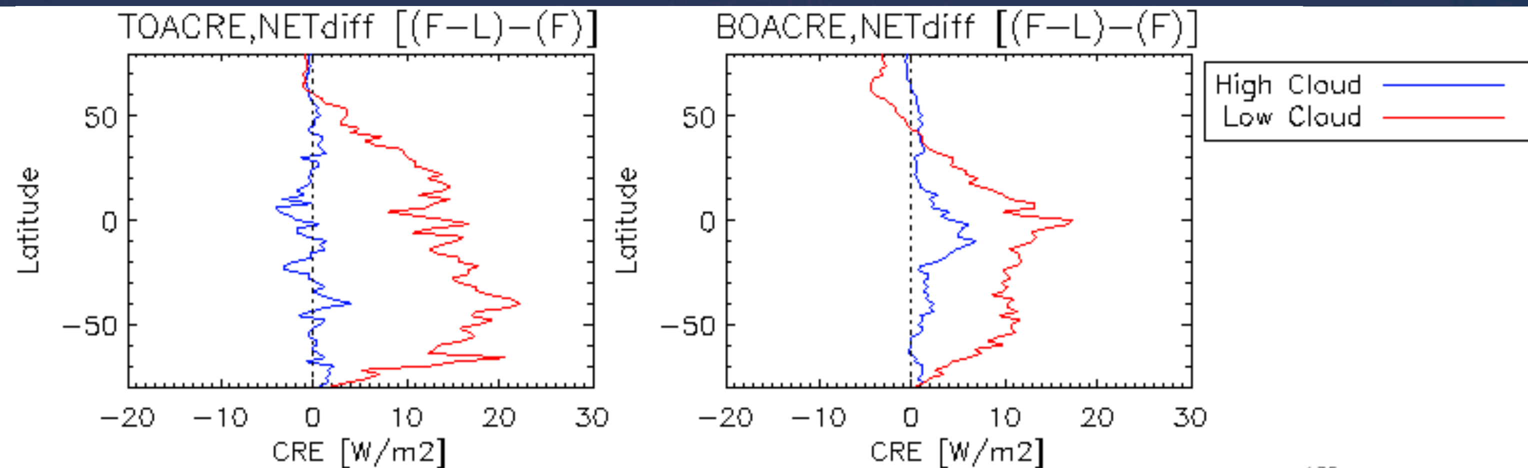


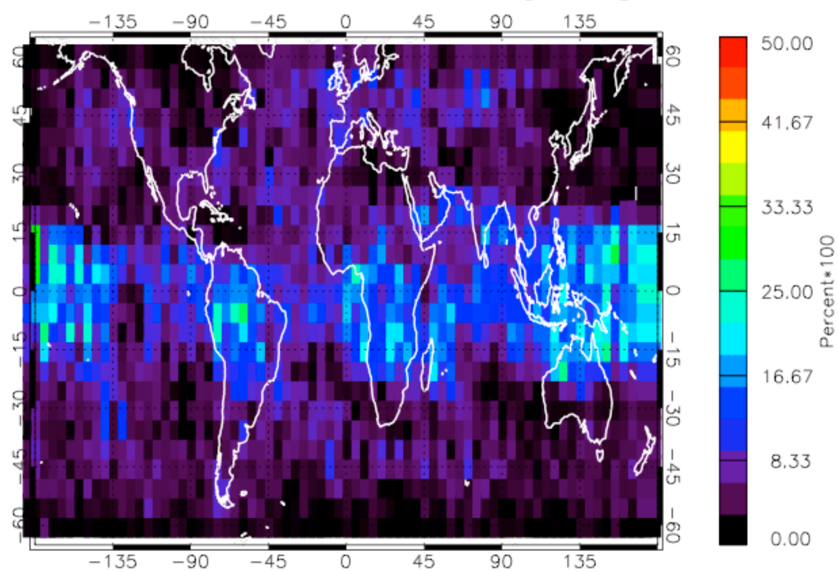
FLXHR-LIDAR-CERES Comparison High Clouds Only

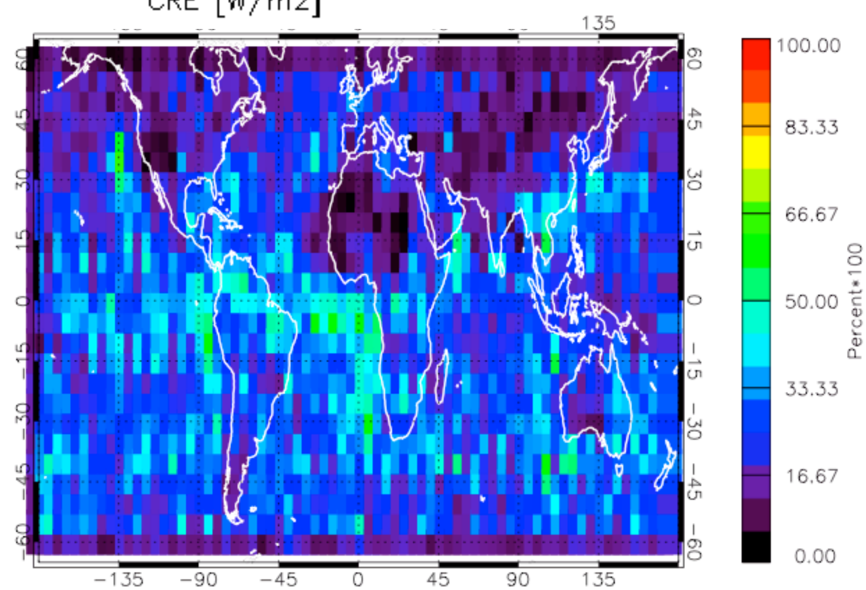


Globally Averaged Impacts of High and Low Clouds: January 2007

Cloud Type	$\Delta F_{up,SW,TOA}$	$\Delta F_{dn,SW,SFC}$	$\Delta F_{up,LW,TOA}$	$\Delta F_{dn,LW,SFC}$
Cirrus	1.4	-1.7	-2.05	0.06
Low	12.6	-13.2	-3.3	6.9







Future Algorithm Delvelopment

- Replace set values of LWC where precipitation is present with values derived from 2C-PRECIP-COLUMN

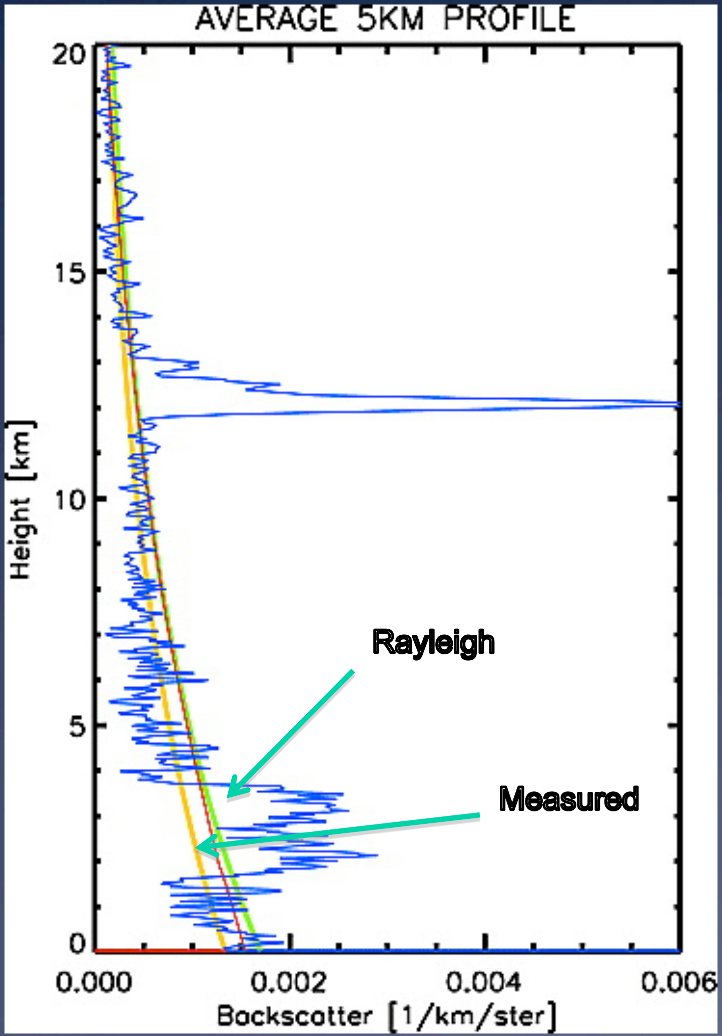
- Add explicit representation of sea ice extent based on AMSR-E sea ice product.

- Continue using CERES analysis to refine from low clouds and CWC-RVOD assumptions.

- Integrate CALIPSO V3 when available

Extra Slides

Properties of Thin Cirrus and Low Clouds



- Thin Cirrus clouds given R_e=30μm and IWC calculated from cloud optical depth

- Exponential fits for Rayleigh and Measured taken from CALIPSO backscatter

$$\beta = A\, e^{-z/H}$$

- Ratio of coefficients yields estimate of OD

$$\frac{A_M}{A_R} = e^{-2\tau_{cld}}$$

- Optical depth used to calculate IWC

$$\tau_{cld} = \frac{3}{2}\frac{IWC}{\rho_i R_e}\Delta z$$

Cloud Type	$\Delta F_{up,SW,TOA}$	$\Delta F_{dn,SW,SFC}$	$\Delta F_{up,LW,TOA}$	$\Delta F_{dn,LW,SFC}$
Cirrus	-0.5	0.4	-1.4	0.04
Low	12.9	-13.7	-2.4	7.4
Cirrus (Both)	2.5	-2.6	-2.5	1.4
Low (Both)	15.4	-16.1	-3.5	8.4